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A historical analysis of the West Coast rock lobster fishery in South Africa with forward-looking implications for policy

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1 Introduction

The newly formed Food and Agriculture Organization (FAO) began collecting data on fisheries in the early 1950s. At this time, the industry faced a period of extremely rapid expansion. Throughout the 1950s and 1960s the growth of yields far exceeded human population growth while fisheries remained largely intact. Over this period, yields rose continuously, and fisheries were seemingly in endless abundance, leading a generation of regulators to believe in the sustainability of global fishery resources (Pauly et al., 2002).

However this belief was found to be false some years later. The first known collapse of a fishery was the case of the Peruvian anchoveta in 1971 (Clark, 1977). Initially this was blamed on an *El Niño* event, however further investigations revealed that extensive overfishing was the most likely cause. With growth in global yields continuing unabated, the stocks of fisheries the world over began to show signs of weakness in the late 1980s, which has continued to this day (FAO, 2012).

Today, most scientists agree that the global fisheries industry is facing a crisis (Myers and Worm, 2003, Montaigne, 2007, Yumiko, 2004). More than half the world's fisheries are at, or above, their maximum sustainable limits with no further room for expansion (FAO, 2012). Worm et al. (2006) estimate that one third of sea fisheries have collapsed, with the rate of decline accelerating. They further go on to predict that this will be the last century of wild seafood.

According to Clark (2006), the worldwide marine fisheries crisis can be succinctly explained as a problem of "too many boats chasing too few fish." Although these fishing fleets can target new fisheries should current fisheries become less productive, the primary issue is that the oceans natural resources are finite.

A noticeable trend in the general decline of global fisheries is that large and valuable species of fish have been most affected (Myers and Worm, 2003).

In this research we highlight just one of those fisheries - the West Coast rock lobster fishery in South Africa. The analysis that follows starts by looking at the history of the fishery and finds that the productivity of the resource has experienced a precipitous decline in the last 50 years. Within this period, the 1980s stands in stark contrast, having displayed noteworthy stability. In light of this, the second part of this paper moves into a detailed exploration of the 1980s, where we assess the strategic interaction between stakeholders in an attempt to understand the dynamics at work. Within this section we explore various methods of analysing the industry, choosing the game theoretic approach introduced by Ostrom et al. (1994). Using this approach we determine why the 1980s period was so stable, and how the dynamics in the fishery have changed since then. In the third section of this research we review these findings to assess the options open to policymakers and in doing so we detail two interesting case studies of best practice in fisheries in other countries. Finally, we use the analyses conducted and the case studies presented to determine four policy implications that would aid policymakers going forward.

2 The history of the West Coast rock lobster fishery in South Africa

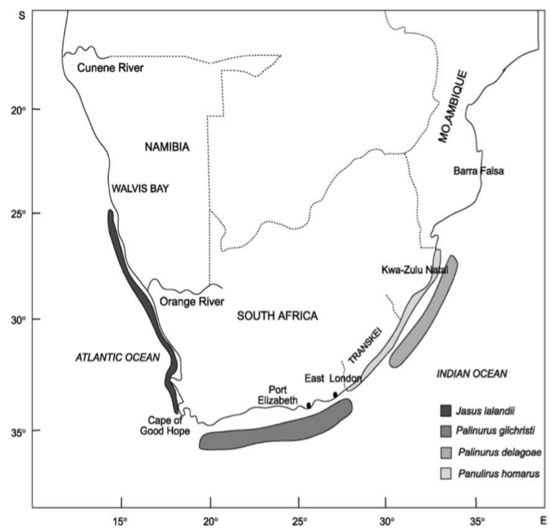
We now contextualise the history of the West Coast rock lobster fishery in South Africa in two parts. In the following section we offer a history of the fishery dating back to the very first records of harvesting, right up to the beginning of the 1980s. The next section assesses at a micro level the fishery in the 1980s, drawing from first-hand discussions with various individuals involved in the 1980s as well as today, fishing industry handbooks published during in the last three decades, and also minutes of meetings held by specific industry groups in the past 40 years.

2.1 The history of the fishery prior to 1980

The West Coast rock lobster *Jasus lalandii* has a long history of exploitation in Southern Africa; it is thought to have been a component of the diet of indigenous inhabitants in the region as far back as the Holocene era, approximately 10,000 years ago (Buchanan, 1988). More recently, in the 19th and 20th centuries, the resource was a sought after food and bait, used particularly by the poorer classes living along the West Coast. In the mid-1800s the rock lobster "was easily caught in vast numbers all the year round" and "to the poor classes of the community, and to misers, this crawfish was a regular godsend" (Pappe, 1853, as quoted by Melville-Smith and Van Sittert, 2005). Astonishingly, in the 19th century the lobster was confirmed as a "food for the poor" and was shunned by the middle-class of the Cape. Today the rock lobster is considered a delicacy and can easily cost restaurateurs R600/kg depending on the time of the year.

In Southern Africa, the West Coast rock lobster is indigenous between 23°S, north of Walvis Bay in Namibia, and 28°S, near East London in South Africa. As shown in figure 1 however, commercial densities are only encountered along the West Coast from 25°S to slightly east of the Cape of Good Hope (Buchanan, 1988).

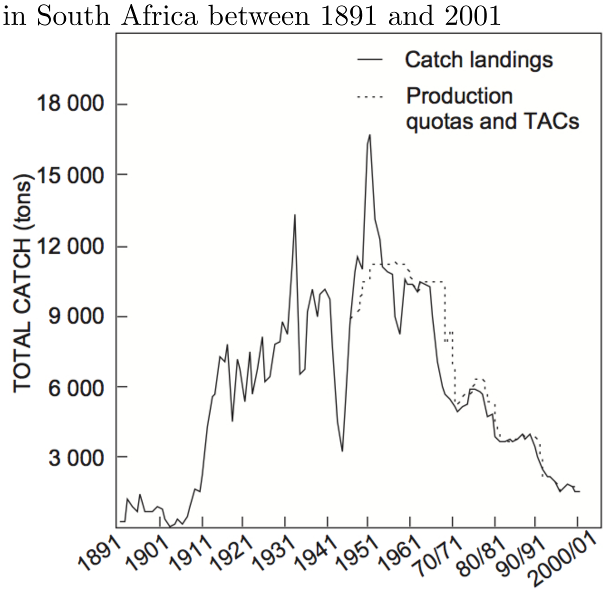
Figure 1: Commercial fishing areas for various lobster types along the coast of Southern Africa



Source: Cockcroft and Payne (1999).

Commercial exploitation began in 1875 with the establishment of a processing plant in Cape Town to can and export lobsters to Europe, where it was seen as a cheap substitute for northern hemisphere lobsters. By 1914 the industry had expanded to include a handful of factories as far up the West Coast as Lüderitz in Namibia. European demand for the lobster increased steadily over this period, while merchants began to freeze lobster tails for export to a growing market in the United States (Thompson, 1913). Immediately after the Second World War production facilities were re-organized and refinanced by the government in an effort to encourage employment and output growth. In terms of this arrangement public funds were provided to private companies for post-war modernization (Daniels, 2007). Subsequently, the rock lobster catch began to expand considerably, reaching a peak in the 1950s at around 16,000 tons per annum. More recently however, the fishery has displayed a protracted downward trend in yield, right up to the present day (figure 2).

Figure 2: Landings of West Coast rock lobster in South Africa between 1891 and 2001



Note: Data presented are derived from exports of canned, frozen, raw and live lobster which are converted into estimated whole live landed weight.
Source: Melville-Smith and Van Sittert (2005).

Catches are now a mere fraction of what they once were at around 2,200 tons per annum, however the resource still plays a vital role in many, mainly impoverished areas, and is still the third most valuable fishery in terms of landed value in South Africa (Johnston and Butterworth, 2005).

Three potential sources of the decline were technological in nature. First, hoopnets were once the most common method of catching lobster, however traps became increasingly more common during the 1960s, having severe consequences for the sustainability of the resource (Schoeman et al., 2002). Second, not only were traps more efficient, but they were also laid by large vessels, which replaced the small dinghies operating without winches or even motors at times. These new vessels had access to previously unfished deeper waters farther off the coast than where hoopnets had traditionally been used. Third, before deck grid-sorters were introduced onto boats in the mid-1970s there was a high discard mortality of undersized animals, which impacted the sub-legal sized portion of the stock and therefore ultimately future stocks of harvestable lobsters (Schoeman, 2002; Crous, 1976).

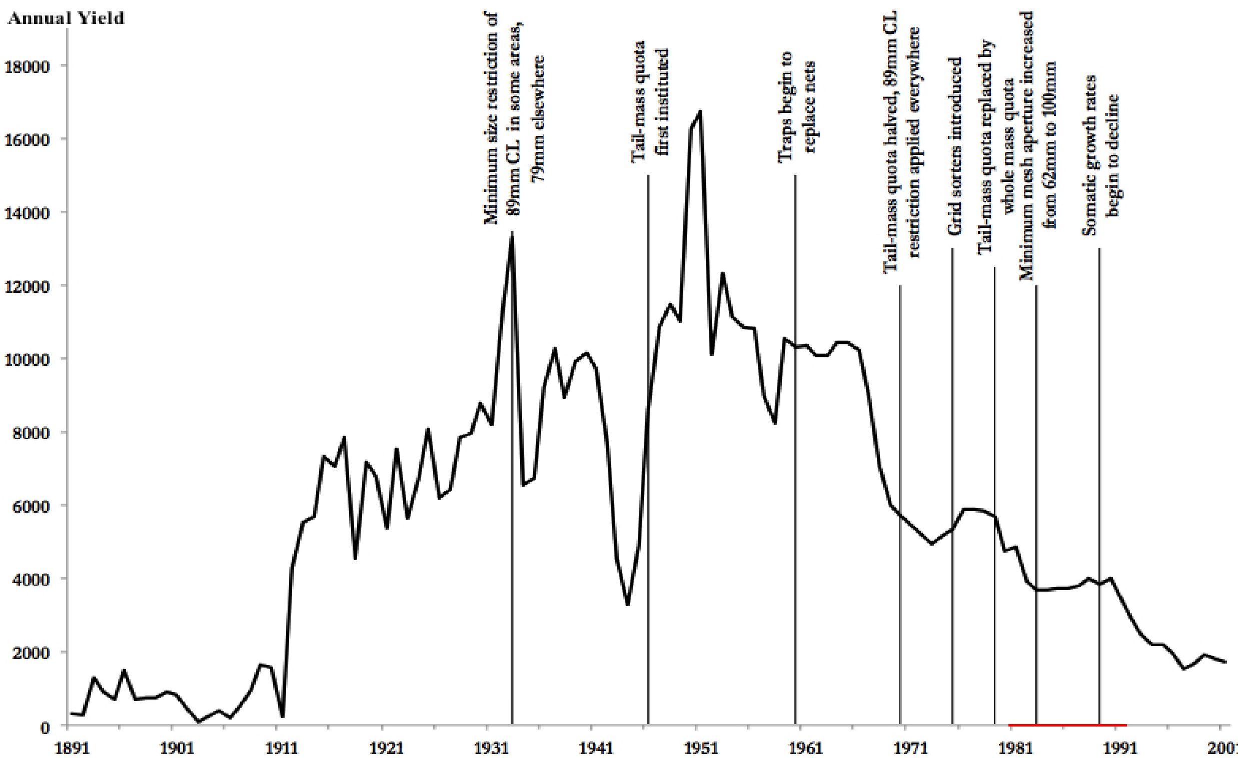
In response to declining yields a number of management measures have been introduced to control the exploitation of the resource. Figure 3 summarizes the variety of measures instituted over time and maps them to historical yields.

The first intervention was introduced in 1933 in terms of which lobster with a carapace length (CL) of less than 89mm were prohibited from being harvested (figure 4).

Importantly, the number of eggs a particular female can produce (the fecundity) is directly dependent on the size of the lobster: larger females produce more eggs per unit of size than smaller females.[1] Large females are capable of producing in excess of a million eggs, with almost all being successfully fertilized (Caputi et al., 2008). This is demonstrated in figure 5 with *Panulirus cygnus*, a rock lobster indigenous to the West

[1]Chubb (1991) suggests that the fecundity of female West Coast rock lobster is equal to 1.92 x (carapace length)$^{2.69}$

Figure 3: History of West Coast rock lobster yields and resource management interventions in South Africa

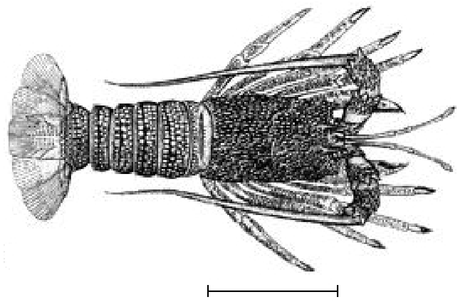


Source: Author's estimates, Melville-Smith and Van Sittert (2005), Cockcroft and Payne (1999).

Coast of Australia. This relationship has obvious implications in terms of the carapace length restriction and how able the resource is to replenish itself.

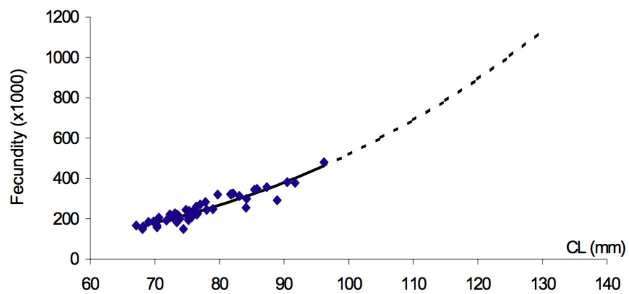
Despite the importance of size on female fecundity and the introduction of size restrictions, catches declined precipitously between 1950 and 1970. It is hypothesized that this is most likely due to overfishing, especially in the northern regions where virtually uncontrolled exploitation took place after 1959 (Cockcroft and Payne, 1999, Mather et al., 2003). According to those familiar with the matter, the fishing grounds in the north were once extremely productive and thought to be practically inexhaustible (Peter Foley, Chief Executive, West Coast Rock Lobster Association, personal communication, May 20, 2011). For example, off the coast of Port Nolloth a very small area roughly the size of only 6 rugby fields would yield 300 tons of rock lobster a year. Over time however, the northern grounds became less productive, and fishers moved southwards towards Lambert's Bay. Figure 6 maps the traditional fishing grounds, now

Figure 4: Morphology of the *Jasus lalandii* indicating the measurement of the carapace length



Source: Department of Primary Industries (2010).

Figure 5: Fecundity of the Western rock lobster *Panulirus cygnus* compared to carapace length



Source: Caputi et al. (2008).

officially demarcated into zones. While the most northern zone was once the most fertile, by the 1990/91 season about 95% of the resource was harvested in zones B, C and D. More recently, in the 1999/00 fishing season, zone D dominated yields with 85% of the commercial catch, compared to 48% ten years earlier (Cockcroft et al., 2000, Mather et al., 2003).

As the annual catch began to wane in the post-1950 period and fishers began to migrate southwards, other measures were instituted to protect the resource. While the carapace length restriction discussed above was likely the most important restriction, other measures also impacted the stock of the resource. These included tail-mass production quotas (which eventually became whole-mass quotas), daily bag limits for recreational fishers, closed seasons, restrictions of mesh aperture and a prohibition on the possession of berried females (figure 3).

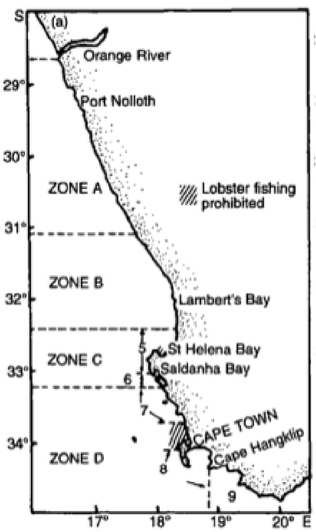
The history of the fishery reveals that the regulatory environment prior to 1980 was *reactive* in the sense that decisive actions were taken only after the resource had suffered a severe amount of overexploitation (figure 3). Between 1950 and 1980 regulations to curtail exploitation seemed to lag the exploitation itself - this is particularly the case in the northern fishing grounds as evidenced by the declining productivity of the resource in those areas.

Within the history of the fishery, the 1980s stand markedly against a fishery in decline. Figure 3 reveals that this decade is the only period in the long history of the resource in which yields were stable for any prolonged period of time. Given this, it becomes valuable to assess at a micro level the dynamics which lead to this outcome.

2.2 A stylized description of the 1980s

After the long downward trend experienced in lobster yields between 1950 and 1980, yields began to stabilize. During the 1980s scientists considered the resource to be sustainably providing annual harvests of between 3,500 and 4,000 tons (Johnston and Butterworth, 2005). In this section we provide a stylized description of the industry during this period in order to better un-

Figure 6: West Coast rock lobster fishing grounds



Source: Cockcroft and Mackenzie (1997).

derstand how this outcome occurred.

During the 1980s an interesting industry structure was present as only two firms were permitted to engage in the process of marketing rock lobster, both on a local and an international basis: South African Frozen Rock Lobster Packers (SAFROC) and Cape Lobster Exporters Association (CLEA) (Mather et al., 2003).

The structure of this value chain dates back to the 1940s when the Crawfish Export Control Act[2] was first promulgated. Prior to this, exports (mainly to the United States of America) were entirely unregulated and hence any individual could export any quality of rock lobster overseas. When the New York Food and Drug Administration warned that imports of rock lobster would be banned if the quality did not improve, the South African Government enacted regulations to curb the export of poor quality rock lobster tails. In terms of this Act, SAFROC was deemed to be the central marketing agency for rock lobster (Du Plessis et al., 1971, van Sittert, 2002).

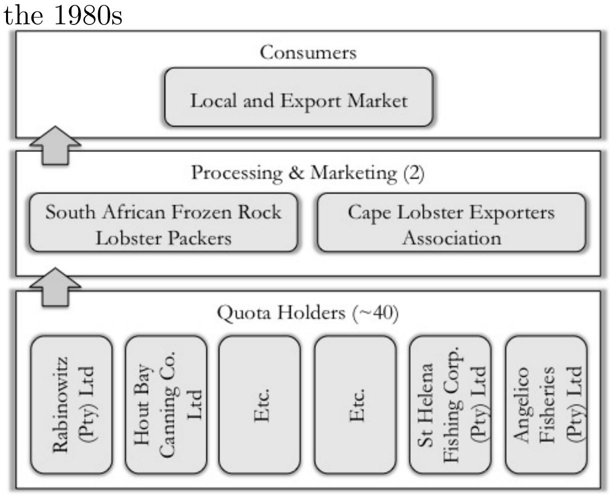
At this stage SAFROC exported rock lobster in either canned or frozen tail form. In the mid-1960s however, a group of lobster quota-holders realised that the produce could be more valuable if it were shipped in whole, live form. They approached SAFROC to facilitate the sale of live lobster in the United States of America, however they declined since they had no interest or expertise in handling or marketing live lobster. Following this, the group of quota-holders lobbied the Government to allow them to sell whole live lobster without the help of SAFROC. The Government acquiesced on condition that they created one association through which the lobster would be marketed, instead of having multiple live lobster marketers (Jeff Louw, CLEA founding member, personal communication, July 13, 2011). In December of 1964 the Cape Lobster Exporters Association was formed in accordance with the Government's wishes (CLEA, 2011).

Neither SAFROC nor CLEA would hold any rights to fish or access the resource themselves. Rather, members of these organisations held quotas in their own name, with the organisations acting as conduits for the marketing, sale and distribution locally and internationally. After processing the lobster, quota holders would transfer them to SAFROC or CLEA for onward sale and distribution. Members would then receive a share of the profits in direct proportion to the amount of lobster transferred annually. Open and honest accounting methods garnered a high degree of trust, with members being able to consult directly with SAFROC and CLEA board

[2] Act 9 of 1940. Later renamed the Rock Lobster Export Control Act.

members on issues that concerned them.

Figure 7: West Coast rock lobster value chain in the 1980s



Source: Author's construction.

Access to the resource was granted by the State in the form of quota allocations, mainly to a limited number of white-owned companies by the so-called Quota Board (Cochrane and Payne, 1999). While there were no regulations to prevent any population group becoming entrepreneurs in the fishing industry, there is some evidence to conclude that certain population groups were discriminated against in terms of attracting quotas (Daniels, 2007, Diemont et al., 1986). For example, only 0,75 percent of the Total Allowable Catch (TAC) in 1994 was awarded to black-owned-companies (Nielsen and Hara, 2006).

In terms of the institutions of the day, the Minister, with advice from scientists, would set the TAC each season, but had no control over the process by which quotas were allocated. Quotas were issued for a period of one year and were reallocated at the beginning of each season according to a set of guidelines. At the beginning of the 1980/81 season, quotas were issued to exactly 40 companies (South African Fishery Yearbook, 1981). According to those familiar with the matter, these were roughly the same 40 companies that received quotas in the previous few seasons, and roughly the same 40 companies that continued to receive quotas for the rest of the decade. In other words, although the quotas were *de jure* short term allocations, they were *de facto* long term allocations (Johan Steyn, rock lobster factory manager, personal communication, June 22, 2011).

The Quota Board also enjoyed a quantum of independence in terms of rights allocations. This fact, coupled with the lack of monitoring and accountability in this process may have led to a degree of corruption, collusion, or discrimination. Suffice it to say that there were certainly many accusations of unfair conduct on the behalf of the Quota Board, despite the purported use of approved guidelines in determining allocations (Mayekiso, Tilney and Swardt, 2000).

As we can see there existed an interesting set of circumstances in the 1980s that deserve further attention. First, the value chain is extremely concentrated. Second, the Quota Board was given the ability to allocate quotas without much interference from the Minister, allowing the issuance of *de facto* long term fishing rights to a select group of fishers. These and other important issues are explored in more rigorous detail in the following section.

3 A game theoretic analysis of the 1980s

We now present an analysis of the fishery in an attempt to understand what led to the stability of the resource during the 1980s. We choose a game theoretic analysis of the fishery because the situation is fundamentally a strategic interaction between groups of individuals, and therefore is well-placed to assist our analysis.

Game theory is a tool for explaining and analysing the strategic interaction between economic agents. It uses mathematics to describe player strategies in sources of conflict and common interest, and predicts what players should do (Luce and Raiffa, 1957). Although there were earlier contributions, modern approaches to game theory are usually attributed to Von Neumann and Morgenstern (1947). Following this work, John Nash, who is probably best known for his work on non-cooperative (1951) and cooperative solutions (1953), expanded the field substantially (he won the Nobel Prize for his work in 1994). These games are structured around players, the constraints they face, the information they possess, and the outcomes they expect given their set of possible actions. These players are assumed to be rational and able to predict outcomes based on their own and their fellow players' actions (Luce and Raiffa, 1957).

We choose a game theoretic model as our method of analysis as game theory allows us to accurately capture the issues faced in fisheries management. We proceed to briefly cover the history of the application of game theory to the fisheries industry, before assessing three key models that we could use to analyse the West Coast rock lobster fishery.

3.1 A history of the application of game theory to the fisheries industry

One of the most enduring and pervasive theories of common-pool resources is H. Scott Gordon's (1954), Anthony Scott's (1955) and Garret Hardin's (1968) collective work on developing a bio-economic model of common-pool resources.

At its foundation, this model argues that any open access conditions of a fishery would lead to the economic destruction of stocks. This is essentially because the cost of catching an extra fish is shared between all fishers in terms of the productivity of the resource in future, whereas the benefit accrues only to that fisher. Each fisher then has the incentive to overfish, leading to the decline and eventual destruction of the resource. Hardin (1968) uses the metaphor of a grassy common shared by many herdsman and argues as follows.

> "[Given the incentives] the rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. And another... But this is the conclusion reached by each and every rational herdsman sharing a commons. Therein is the tragedy. Each man is locked into a system that compels him to increase his herd without limit - in a world that is limited. Ruin is the destination toward which all men rush, each pursuing his own best interest..."

Given this, policies designed to avert the destruction of common-pool resources should include external intervention. This is most often a strong central government armed with knowledge, monitoring abilities, and the power to effectively control access to the resource. We will discuss the applicability of this model to our analysis in the following section.

The first paper to apply game theoretic methods to an analysis of the fishery industry itself (rather than common-pool resources as in the model above) was Munro (1979). In this paper he argues that the issue of managing transboundary fishery stocks, those stocks that are not within only one country's Exclusive Economic Zone (EEZ), would require a joint approach by all parties and therefore applies the theory of bargaining, or cooperative games, to the problem. In cooperative games players are able to form binding commitments, such as those that are legally enforceable. In non-cooperative games this is assumed be impossible, and hence any cooperation must be self-enforcing (Mas-Colell, Whinston and Green, 1995).

Munro (1979) investigated how asymmetry in players in terms of discount rates, cost of fishing, and consumer preferences, can impact the catch shares of the players. In this analysis he simplified the game to include only two players - an approach that many game theorists take. One of the conclusions of Munro's (1979) work is that the joint management of a resource where players are asymmetric is greatly simplified by the existence of side payments (essentially transfers of money between players).

One year after Munro first used game theory in the context of fisheries management, Levhari and Mirman (1980) published their influential paper on "fish wars". In their analysis they highlight two important features of fisheries management that allow a game theoretic analysis to be useful: first, each player must take into account the other players actions, and second, the underlying stock is affected by both players' decisions (Sumaila, 1999). This is similar to the game theoretic notion of "strategic interdependence" where each agent recognises that the outcome of the game in terms of profits or utility depends not only on that agents' actions, but also the actions of other players in the game (Mas-Colell, Whinston and Green, 1995).

Also in 1980, Clark (1980) wrote a game theoretic paper exploring restricted access to common-property resources such as fisheries. For the first time, it was shown that for a limited entry system with at least two players, the non-cooperative game results in overfishing.

Following these pioneering papers by Munro, Levhari and Mirman, and Clark, many other contributions were published, mostly in the 1990s, applying game theory to fisheries (for a full review consult Bailey, Sumaila and Lindroos (2010)). These games typically modelled fisheries shared between only two players. Although there are multiple examples of fisheries being shared by more than two groups, game theorists reduce the complexity by aggregating actors into two groups of similar players. For example, Armstrong and Flaaten (1991) groups fishers by gear-type in the Arcto-Norwegian cod fishery, while Sumaila (1995) models the interaction between offshore trawlers and coastal vessels. In Munro's (1979) paper he groups players by nationality. Similarly, Kennedy (1987) groups fishers into Australians and Japanese, both targeting Southern bluefin tuna. Here Kennedy (1987) concluded that the optimal outcome is the joint management of the resource and a cooperative agreement between nations which resulted in the total exclusion of the Australians from the fishery, subject to compensation through side payments.

In a paper authored by Walker and Gardner (1992), a general model of common-pool resources is presented which is able to account for the concept of *safe yields*. Here the usage of the resource has direct impact on the stock of the resource in ways typically seen in many natural common-pool resources. For example, there are specific usage rates at which the resource has a zero probability of being depleted, and similarly, rates that imply the destruction of the resource with a positive probability. This is particularly pertinent for fisheries, given the natural ability of this resource to replenish stocks over time, where yields are within certain ranges.

In *Rules, Games and Common-Pool Resources*, Ostrom et al. (1994) interrogate the use of game theory in the context of common-pool resources. They approach the issue of modelling the strategic interaction between players by using basic finitely repeated non-cooperative games, within a broader institutional analysis framework. Ostrom et al. (1994) further break down the analysis by introducing an analytic method that separates *appropriation* problems from *provision* problems. In the context of fisheries, an appropriation problem relates to issues of apportioning the benefits of that fishery, whereas provision problems relate to issues around maintaining the resource and avoiding its destruction (Ostrom et al., 1994). It can be understood that appropriation problems involve the *flow* of the resource, while provision problems relate to the *stock* of the resource. Although most frequently, these problems are nested as one problem, the separation of problems is specifically helpful in deep-sea fisheries where there are issues related to more than just the survival of the resource, such as the allocation of the resource between countries.

When Sumaila (1999) published a review of the applications of game theory to fisheries in 1999, much of the work still focussed on the two-player framework introduced by Munro (1979). Subsequent to this, research focussed on extensions of this model. In Sumaila (2002), the two-player game was extended to study the efficiency of marine protected areas, rather than simply the catch shares between players. This paper developed a bio-economic model to assess the differences in expected efficiency under cooperative and non-cooperative management. Perhaps unsurprisingly the paper concluded that both stock biomass and rent from the fishery are higher under cooperative management by the players.

While most studies have used a single-stage structure, there have been notable examples of multiple-stage or sequential games. In sequential-play games players take turns making decisions, and usually players are able to observe the actions of other players before making their own decisions. Benchekroun and Van Long (2002) model a transboundary fishery where one player has a first-mover advantage. They find that in general the sequential nature of the model leads to a more conservationist approach being adopted by parties. Sumaila (1995) develops a two-stage game where players decide on the fishing effort in stage one, and their optimal catch-shares in stage two. Ruseski (1998) has players choose the number of allowable firms in the fishery in stage one, and then optimise their catch-shares in the competitive second stage. Hannesson (1995) develops a sequential-play game to consider the possibility of a cooperative solution being self-enforcing, whereas Laukkanen (2003) allows the catch of one agent to occur first because they target the feeding grounds, followed by the other agent who targets the spawning grounds. In this research Laukkanen (2003) also models stochastic shocks in recruitment in the fishery to show that these shocks endanger any cooperative agreements if they are prevalent and the actions of each fisher are not observable.

In Laukkanen (2001) the Northern Baltic Salmon fishery is modelled using a dynamic game theoretic model with four rounds. Here, to accurately account for the dynamics of fishing for salmon in this area, four fisheries harvest the northernmost stocks in turn: first is the commercial offshore fishers, then the commercial inshore fishers, followed by recreational fishers in rivers, and finally recreational fishers in estuaries.

Kronbak and Lindroos (2006) develop the most complex multi-stage game where in stage one authorities choose their level of regulation, in stage two they choose the level of effort and control, in stage three fishers choose their coalition structure and in stage four fishers choose their optimal effort. The authors do this to combine the idea of coalition formation and the level of regulation and enforcement in the industry.

As is evident, there has been considerable application of game theory to the strategic interaction between stakeholders in many fisheries. Given that there is much research to draw from, in the next section we focus on three of the most appropriate models discussed above, and adopt one that is the most useful for our analysis of the West Coast rock lobster fishery in the 1980s.

3.2 Choosing a game theoretic model of analysis

Given this brief history of the application of game theory to fisheries, we highlight three models that we can draw on to analyse the rock lobster industry in the 1980s. Each of these is discussed in turn along with an explanation of why the model should be used here or not, leading us to the conclusion that the framework used by Ostrom et al. (1994) is the most relevant for our analysis.

3.2.1 Gordon, Scott, and Hardin's bio-economic model of common-pool resources

As mentioned above, one of the most common models of common-pool resources is Gordon (1954), Scott (1955) and Hardin's (1968) collective work on developing a bio-economic model of common-pool resources. While this model has been used numerous times in the past, and especially in the early application of game theory to common-pool resources, we choose not to use it in our analysis for four reasons. First, there are many problems that common-pool resources face, not only overuse as predicted by the bio-economic model.

Second, in hundreds of documented cases appropriators have cooperatively designed arrangements that limited and coordinated their use of natural resources (see Schlager, 1990, 2002, and Ostrom, 1990, for a discussion of these). This outcome is precluded by the bio-economic model of common-pool resources.

Third, the model predicts that communication between resource users has no significant result on the outcomes predicted. Many empirical studies have shown this to be false (Ostrom, Gardner and Walker, 1994).

Fourth, in many respects common-pool resource situations are much more complex than the bio-economic model predicts. Individuals are not always single-mindedly trapped in their own tragedies, nor are government regulators always omniscient and omnipotent. Rather there are complex and strategic interactions between resource users, regulators and the common-pool resource itself.

While this model can be quite insightful for understanding the basic issue faced in most common-pool resources, it has been discredited in recent times most notably by Elinor Ostrom and Edella Schlager. As Schlager (2002) strongly advises, "the bio-economic model does not capture critical dimensions of common-pool resource dilemmas, or human behaviour, and is therefore inappropriately used in all circumstances."

3.2.2 Walker and Gardner's model of the probabilistic destruction of common-pool resources

Walker and Gardner (1992) use a non-cooperative game theoretic model to introduce the concept of a *safe yield* into the game, which models the regenerative process of renewable resources such as fisheries. As mentioned above, this is a key model for us given its ability to account for issues commonly encountered in the fisheries industry.

In this model the authors use the theory of N-person finitely repeated games. Each player i has an endowment of resources e_i which can be invested in the common-pool resource, or invested in a safe, outside activity. The payoff to each appropriator from investing in the resource depends on the aggregate investment made by all players.

Using this model they test the expected outcomes as predicted by game theory using a laboratory experiment. Their primary results are first, that where the safe zone is a single point, the resource is rapidly destroyed in accordance with the predicted outcome, and second, where the safe zone is an interval group, behaviour focuses on the best available equilibrium for the group in some cases, but in general this cannot be sustained and the resource is destroyed.

While this study has merit, it is not applicable to this research for two reasons. First, the model is not able to take into account changes in the rules of the game, or, more importantly for our purposes, expected changes in the rules of the game. Secondly, this model does not take into account the various options or strategies open to the regulators of the resource. For our use we require that regulators are given the option to roll over quotas to the same finite set of quota holders, or choose not to roll over quotas and allocate the quotas to a new set of fishers. For these two practical reasons we must rule out this model as a potential method of analysis.

3.2.3 Ostrom's method of game theoretic analysis

Ostrom et al. (1994) present a method of analysing common-pool resources using game theory, and offer empirical and laboratory tests of these models.

As with much of the work conducted by Ostrom, *Rules, Games and Common-Pool Resources* uses an Institutional Analysis and Development framework as a tool of organising the work. They present a method of using non-cooperative game theory as a formal language for applying this framework to common-pool resources.

We will use the basic game theory framework introduced by Ostrom and her colleagues here for three key reasons. First, as we will see the mindset of the fishers in the 1980s was an important part of why they acted the way they did. The method of using basic game theory along with expected preferences of players introduced in Ostrom et al. (1994) is perfectly able to incorporate this detail. Models offered by Walker and Gardner (1992) however are made increasingly unmanageable by this. Second, this method can effectively account for the ability of the regulators to choose between strategies, whereas other models assume that regulators are outside the realm of the game. Third, the model is logical, malleable and is supported by empirical and laboratory testing (Ostrom et al., 1994).

In this research they address common-pool resource problems as N-person, non-cooperative games. They then conduct empirical and laboratory tests to determine the validity of the results predicted by the games. We follow their approach of using a basic game theoretic model as the fundamental platform of analysis, tweaking it to suit our needs by limiting the players to two (rather than N).

In our analysis we will follow the lead of Ostrom et al. (1994) by using the concept of a Nash equilibrium to predict the outcome of that strategic interaction. Informally, a Nash equilibrum can be understood to be an equilibrium in which no player has the incentive to deviate from his chosen strategy (Dixit, Skeath and Reiley, 1999).

3.3 An analysis of the rock lobster fishery in the 1980s

Following this methodology, we characterize the industry in terms of simple game theory. In this respect we move from the broad accounts presented above to understanding at a much finer level of detail the dynamics that existed in the 1980s.

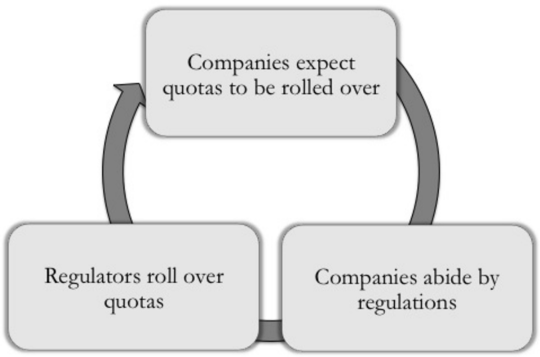
During this period of time, the industry encompassed three major actors; the quota-holding companies, the industry regulators, and those excluded from holding quotas. We will make a simplification and group the two processor companies and the 40 or so quota holders together for convenience as “companies”. Similarly, we will group the Quota Board and the Interim Quota Board, as discussed in detail later, as “regulators”. When we concentrate our focus on the interaction between these three actors we uncover an interesting, and possibly collusive, alliance between companies and the regulators, and some key incentives too.

During this period there existed a strong degree of cooperation between regulators and the companies. Individual relationships between the fisheries management authority and the companies were strengthened by the fact that they shared a common culture in terms of educational background, language and value systems (Mayekiso, Tilney and Swardt, 2000). The homogeneity between regulators and the quota-holding companies created a spirit of cooperation, engendering a high degree of comanagement with respect to stock assessment and management procedures.

There also existed a focus, in the minds of the companies, on the long term sustainability of the resource. This is in part due to the *de facto* long term nature of the property rights issued by the Quota Board and also simply because the demise of the fishery would lead to the demise of the industry. More importantly however, the confidence the industry had in the Quota Board in its implicit agreement to grant rights to a select group of individuals would plausibly have affected the degree of cooperation between these actors. The repetitive reallocation of rights, year after year, to a privileged few companies would have generated at least a quasi-collusive relationship between them. The companies therefore had the expectation that the regulators would continue to roll over the quota allocations so long as they did not overfish to any great extent. In terms of incentives then, the companies had an incentive to behave in accordance with the regulators’ wishes, so long as they had the expectation that regulators could roll over the quotas annually. Figure 8 highlights the continuity of this relationship.

The excluded fishers however, were not involved in this industry to any great extent (Peter Foley, Chief Executive, West Coast Rock Lobster Association, personal communication, May 20, 2011). In order to ensure the exclusion of

Figure 8: The relationship between company expectations and the rolling over of quotas



Source: Author's construction.

these actors some degree of monitoring and enforcement was necessary, a task made easier by the structure of the value chain. In terms of this structure, quota holders were required to transfer their produce directly to one of the two processors, who would then process, package and sell the items either to the export market or to the local market. Regulators would then simply monitor the export market through customs at any port, and monitor the local market by checking invoices at restaurants. Exports would have to be conducted under the auspices of one of the two processors, otherwise the export would simply be denied. Local restaurants would also need to prove that their stock came from one of the two processors in terms of an invoice.

Monitoring and enforcement was focussed at two points and hence it was much easier to quell the parallel black market for lobster. In game theoretic parlance, the regulators had perfect and complete information (Binmore, 1992). By this we mean that all players are fully aware of the strategies available to all players and the payoffs associated with these (complete information), and also that players are able to see all of the moves made in the game (perfect information). These assumptions are plausible because firstly, both players know the strategies available to each other at any point in the game. Secondly, regulators had a high degree of certainty around whether fishers were complying with the regulations or not.

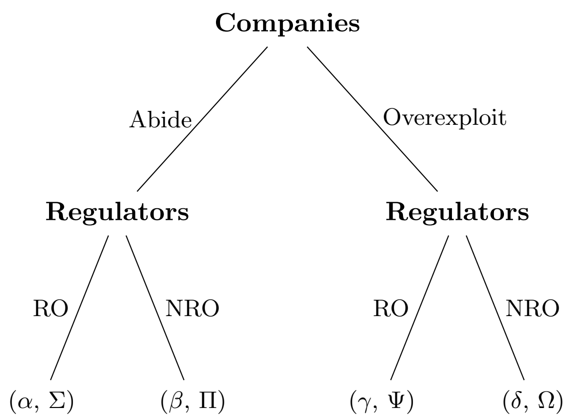
In contrast, today there are 19 processing plants with over 2,800 employees, making efforts to monitor the industry much more challenging. Enforcement is now focussed mainly on landing sites. The sheer number of these sites, and the fact that many small craft do not need proper landing sites make it all the more difficult. In the early 1990s the law was amended in terms of which quota holders had access to a number of feasible processors and marketers (Mather et al., 2003). The creation of this diversified market for lobster presented more opportunities to export through illegal means.

Note also that during the 1980s excluded fishers were predominantly coloured or African, and faced large obstacles in getting quotas for themselves. Although the regulations of the day did not explicitly exclude Africans or coloureds from attracting quotas, the quasi-collusive relationship between the largely white-owned companies and the regulators would have impeded the chance of successfully receiving a quota (Mather et al., 2003, Daniels, 2007, Diemont et al., 1986).

The industry was therefore dominated by two actors, the companies and the regulators. We can summarize the strategic interaction of these players in formal game theory, as shown in figure 9. We can ignore the excluded fishers for the time being since any strategy they choose to play has minimal effect on the payoff of other players.

There are some notable nuances in the game

Figure 9: Generic strategic interaction between companies and regulators in the 1980s



Note: Companies payoffs are listed first, regulators payoffs are listed second.
Source: Author's construction.

presented that are worthy of our discussion. First, we have assumed a sequential game where companies first choose whether to abide by the regulations or overexploit the resource in terms of size and yield restrictions. Subsequently, the regulators choose whether to roll over the quotas to existing companies, hence playing Roll Over (RO), or to not roll over quotas, hence playing Not Roll Over (NRO), and allocate quotas to new or other existing quota holders. Second, we have assumed perfect and complete information, and as mentioned earlier we are confident that these assumptions are plausible.

Using some basic assumptions we can hypothesize the rank order of certain payoffs and hence predict the outcomes of this strategic interaction. Beginning with the more benign assumptions, we postulate that if companies choose to abide by the rules then the regulators would prefer to roll over the quotas to those responsible firms. Confronted by overexploitation, the regulators would be reluctant to renew the rights of culpable quota holders. From this we know that $\Sigma > \Pi$, and $\Omega > \Psi$.

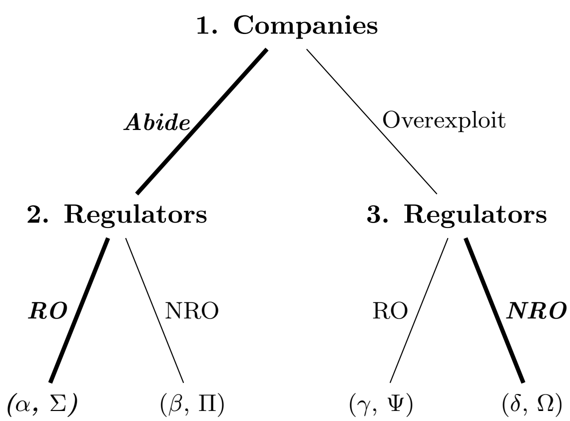
In terms of ranking the payoffs attributable to companies, we know that companies will always prefer regulators to roll over quotas, rather than not rolling quotas, and hence $\alpha > \beta$, and $\gamma > \delta$.

In order to specify the final preference relation we should note that we have assumed that this is a game of complete information and hence players are fully aware of the strategies available to all players and the associated payoffs (Binmore, 1992). Because of this, companies are able to use *backward induction* to predict what regulators are likely to do at future decision points (Aumann, 1995). Hence, companies know that if they choose to abide by regulations, regulators will choose to roll over the quotas. Conversely, if companies choose to overexploit the resource, the regulators will choose to not roll over the quotas (as mentioned above, we know that $\Sigma > \Pi$, and $\Omega > \Psi$). Companies therefore choose between getting α if they abide by regulations or δ if they do not.

In order to determine the ranking of these payoffs we can assess the likely gains of choosing to overexploit the resource, in comparison to the benefits of abiding by the regulations. Mather et al. (2002) present evidence to conclude that quota holders during this period did not in fact have much excess capacity to overfish. For example, in 1992 the total harvesting capacity of the commercial West Coast rock lobster fleet was roughly 2,414 tons, while the TAC attributable to commercial fishers was set at 2,176 tons that season. Hence, we hypothesize that choosing to overexploit the resource as much as possible and not have quotas rolled over would not have been preferred to fishing legally and having the quotas rolled over. Given the data presented by Mather et al. (2002) we are confident that companies prefer to fish legally and have quotas rolled over, and hence $\alpha > \delta$.

Let us now walk through the preference relations to determine the equilibrium of this interaction. We present figure 10 below for convenience.

Figure 10: Generic strategic interaction between companies and regulators in the 1980s



Note: Companies payoffs are listed first, regulators payoffs are listed second.
Source: Author's construction.

To determine this equilibrium we should assess what each player is likely to do at each decision point in the game. If the game were to reach the decision point labeled "2. Regulators", regulators would prefer to roll over quotas to companies since they have abided by the regulations and have proven themselves trustworthy. Similarly, were the game to reach the decision point labeled "3. Regulators", regulators would prefer to not roll over quotas as the companies have chosen to overexploit the fishery. Knowing the decisions that regulators are likely to make at these decision points, companies know that they must choose between receiving a payoff of α were they to abide by the regulations, and δ were they not to. As above, we postulate that $\alpha > \delta$ and as such companies will choose to play abide at the first decision point. The moves each player is expected to play at each decision node is emboldened and italicised in figure 10 to show the equilibrium.

This equilibrium can be written as ((Abide), (Roll over quotas if companies play abide, Not roll over quotas if companies play overexploit)), with the payoffs being (α, Σ). Here we have used the method of backward induction to solve for this solution, and hence the equilibrium accords with a refinement introduced by Selten (1975) called a *subgame perfect Nash equilibrium*. This equilibrium qualifies as a subgame perfect Nash equilibrium because the behaviour of the players, as defined in the equilibrium, represents a Nash equilibrium in all subgames of the full game (Dixit, Skeath and Reiley, 1999). Hence each player makes optimal decisions at every decision point.

In formulating this model we have hypothesized various preference relations. What we have yet to discuss is the plausibility of our model in terms of the information each actor possessed at the time. We should be comforted by the fact that the game is relatively simple for agents to understand, is repeated many times over, and involves large stakes. In conditions such as this, our assumption that agents know their possible strategies, their opponent's strategies, various preference relations and payoffs, should be satisfied (Camerer et al., 1993, McCabe, Rassenti and Smith, 1996, Aumann, 1981, Hechter, 1990).

In terms of explaining the industry in the

1980s, the model tends to do very well. It not only substantiates why the same 40 companies received quotas each year, but also why the resource was so stable over this period.

A noteworthy feature of the model is that it is fairly robust in the sense that regulators have the ability to punish the companies. For example, if the companies overexploited the resource the regulators can punish them by excluding these companies from receiving quotas. Given this we would expect the companies to abide by the rules, and the regulators to roll the quotas over to the same set of companies. As discussed previously, this prediction is upheld in the data. The model also then predicts that there existed a high degree of co-management of the resource and hence stable or even increasing yields. Indeed the data do show that the resource was possibly the most stable it has been since commercial exploitation began (figure 3).

The ability of regulators to punish companies gives the equilibrium a degree of robustness, however the model also highlights the pivotal role expectations play in engendering cooperation between companies and regulators. It is because companies expect regulators to roll over the quotas so long as they abide by regulations that this outcome exists in the first place. Indeed the *achilles heel* of this equilibrium takes the form of these expectations, for if they were to break down this self-fulfilling prophecy would fail to exist.

So far we have analyzed at a very micro level the actors in the industry, the strategies of the actors, expectations they have, their preferences and information they likely hold. We have used this to create a game theoretic model of the strategic interaction between players and have found that the model fits the period fairly well in terms of explaining the outcomes seen. In the next section of this research we test the model by assessing whether it can be used to explain the outcomes observed in the period subsequent to the 1980s.

3.4 The *interregnum* period

The 1980s and the 1990s were vastly different decades in South Africa's lobster fishery. In the 1980s, the right to access marine living resources were held tightly in the hands of a few individuals, with little recognition of the rights of other potential fishers. At least since the democratization of South Africa in 1994 an expectation proliferated among many previously excluded stakeholders that the country's new democratic principles would manifest in a series of new fishing policies (Daniels, 2007). Indeed an array of policies to include the newly recognized stakeholders would emerge in the late 1990s. These policies would however take many years to be drafted, discussed, debated, modified, re-drafted and eventually promulgated. During the mid-1990s then, the industry was caught in a state of flux while new policies were being created, potentially affecting the incentives of actors in the industry. We begin this section by attempting to profile the salient features of the *interregnum* landscape. We then move on to review our earlier model to test its ability to explain the outcomes witnessed in the post-1980s period.

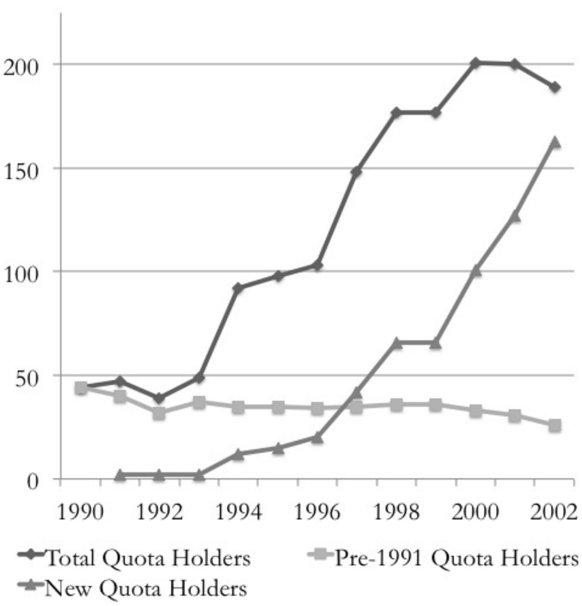
South African regulators had two - often opposing - challenges in terms of the creation of a new fisheries policy. First, fisheries needed to be managed effectively in a such a way to ensure the sustainability of the resource. Second they needed to solve the quandary of how to deal with the vestiges of apartheid (Cockcroft and Payne, 1999). The raised expectations that the democratization of the country brought, coupled with the multifarious array of challenges faced within the rock lobster fishery, made for a demanding environment in which to set regulations.

The process of formulating these new, more equitable policies was initiated by the Minister of Environmental Affairs and Tourism in October 1994. In the following years the newly mooted Fisheries Policy Development Committee drafted a Green Paper and a White paper, culminating in a presentation to the Minister in 1997 (Anonymous, 1997).

Following this, further consultation took place with the various stakeholders interested in the fishing industry, including communities. The regulators, being the Parliamentary Portfolio Committee on Environmental Affairs, took great pride in hearing all those who felt they had something to contribute. Ultimately, the White Paper of 1997 and these consultations concluded with the Marine Living Resources Act, which was promulgated in September 1998. The new Act differed greatly from the old Act by giving the Minister more power, and by abolishing the Quota Board. In light of the need for cooperative governance and stakeholder buy-in, more representative advisory and consultative bodies were created and the challenge put to the organization administering the Act to ensure that these bodies could immediately act the way that they were designed. These organizations included the Fisheries Transformation Council, the Chief Directorate of Sea Fisheries, and the Sea Fisheries Research Institute.

This new fisheries policy had at its heart three central pillars of sustainability, equity and the stability of the industry (Cockcroft and Payne, 1999). In terms of the sustainability of resources, stock assessments indicate that the rock lobster fishery was under extreme pressure during this period - the TAC of roughly 4,000 tons per annum in the 1980s was steadily decreased to as low as 1,520 tons per annum in 1995/96 (Johnston and Butterworth, 2005). According to the Department of Environmental Affairs and Tourism (2005) this decline was the result of "large and unsustainable catches taken during the first half of the 20th century." Anecdotal evidence confirms that the resource was the victim of overfishing on a massive scale during that period (Tony Leiman, Associate Professor, UCT, personal communication, April 29, 2011, Susan Holloway, Senior Research Officer, UCT Marine Resource Assessment and Management Group, personal communication, April 6, 2011).

Figure 11: Number of West Coast rock lobster quota holders between 1990 and 2002



Source: Fishing Industry Handbook (1992-2002).

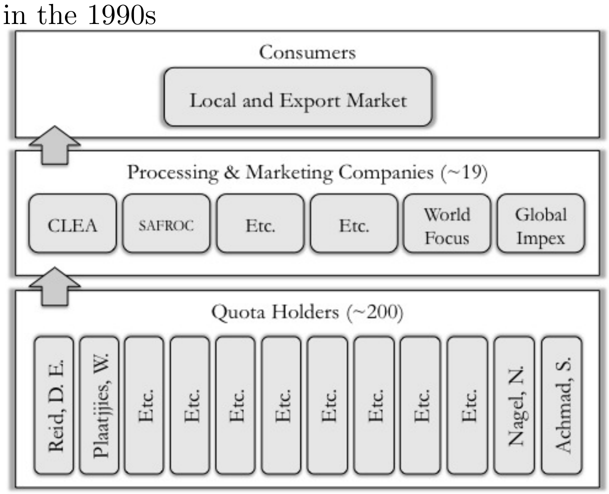
The number of individuals holding quotas increased markedly over this period. As can be seen from figure 11, in 1990 49 predominantly white rights-holders controlled the West Coast rock lobster TAC. In contrast, by the end of 2003 over 1,000 rights had been allocated to nearly 200 individuals, with around 70% of these rights being allocated to previously excluded fishers (DEAT, 2005). To accommodate this rapid increase in the number of quotas issued, the average allocation per quota correspondingly decreased; average allocations decreased from 56 tons in 1992 to 7 tons per quota in 2002.

Not only were quotas spread more evenly across the fishing community, they were also allocated in a more equitable fashion. As discussed previously, in the 1980s the overwhelming majority of quotas were held by a select group of white individuals. By 2001 however, roughly 70 percent of rights were allocated to previously disadvantaged race groups (DEAT, 2005). The duration of these quotas was significantly lengthened from the original 1 year to a period of 10 years in order to facilitate the stability of the industry and to encourage fixed investment.

In terms of the current fisheries policy due regard is given to those previously disadvantaged race groups, as well as women. Other quota allocation criteria include compliance with legislation on skills development, corporate social investment, local economic development, the ability to add value through processing and whether the applicant relies to a large degree on income derived from the West Coast rock lobster fishery.

In the early 1990s the processing and marketing of rock lobster was freed up entirely. Nowadays quota holders have an array of potential marketers and processors to choose from, rather than the original (Hobson's) choice between SAFROC and CLEA. The large increase in the number of quota holders, as well as the opening of the market has substantially changed the value chain. As figure 12 shows the market is far less concentrated, especially in the processing and marketing segment with 19 firms in the 1990s, compared with just 2 firms in the 1980s. As previously discussed, this has made monitoring and controlling the industry substantially more difficult.

Figure 12: West Coast rock lobster value chain in the 1990s



Source: Author's construction.

Now that we have characterized the *interregnum* period, we turn our attention towards the model we created in the previous section and assess its ability to explain the outcomes witnessed in the 1990s.

In terms of the model presented earlier the regulators had the option to roll over the quotas to the same set of 40 companies or not. The regulators, in the form of the Quota Board, had some degree of discretion over who was to receive quotas, and who was to be excluded. Over time an expectation formed in the minds of the companies that the Board would continually roll over quotas so long as the companies chose not to overexploit the resource. This created what we have called *de facto* long term fishing rights, and incentivized the fishing companies to abide by the regulations leading to the sustainable exploitation of the resource seen in the 1980s. These expectations and *de facto* long term fishing rights were at the core of this equilibrium.

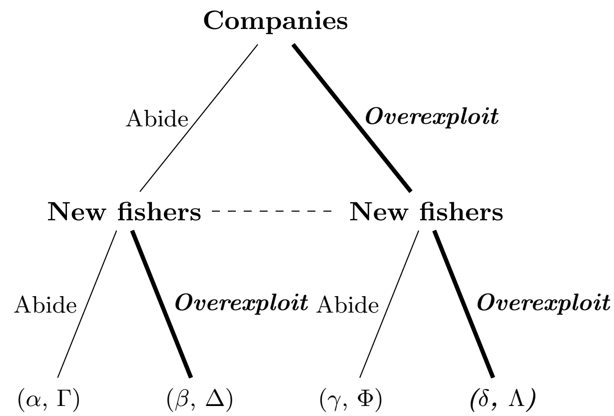
As mentioned above, in the mid-1990s the Quota Board was replaced with a more regulated body. Although there were allegations of corrupt allocation procedures, in general the new so-called Interim Quota Board had much less discretion over who received quotas (Daniels, 2007). Thus, in the 1990s the regulators had only one strategy, and that was to allocate quotas as dictated by policy.

When we first created the model above we made the assumption that the excluded fishers had practically no influence on the payoffs of the regulators and the companies. In the context of the 1990s this assumption is not valid, given the focus of policy on an equitable distribution of quotas to all stakeholders, and especially to the previously excluded race groups. These players must now enter our model as actors in the game since the decisions they make influence the payoffs of other players. Conversely, the regulators no longer have more than one strategy and hence can be excluded from the game. Given this we present our model once more, with updated players, payoffs and strategies in figure 13.

As before, we group new quota holders as one player in this game, and name them "new fishers" for convenience.

It is worth explaining in some detail the assumptions this new structure encompasses. First, we have dropped our previous assumption of perfect information, as indicated by the information set between nodes two and three. Formally, an information set drawn between a

Figure 13: Generic strategic interaction between companies and new fishers in the 1990s



Note: Companies payoffs are listed first, new fishers payoffs are listed second.
Source: Author's construction.

player's decision nodes restricts the ability of that player to know which specific node he is at (Mas-Colell, Whinston and Green, 1995). This manifests because that player was not able to observe what had previously transpired in the game. We do this because it is entirely logical that companies would have to move in ignorance of what the new fishers would do, and similarly, new fishers would need to move in ignorance of what the companies have done. This contrasts with the 1980s where regulators had a strong idea of whether companies were abiding by the regulations or not.

Second, although we have specified the game in the form of a game tree (an extensive form game), the lack of information players have regarding the moves made by each other means that the new fishers must make their choice without knowing what strategy the companies have played.

Again, we can assume certain preference relations, given the interaction these players are engaged in. Regardless of whether the companies choose to abide by the rules or overexploit the resource, a new quota holder would prefer to overexploit the resource. This is because the benefit the player receives from overexploiting the resource is allocated squarely on that person, whereas the cost of that action is distributed across all players, in terms of lower future yields. We are confident in this for three reasons: first, the ability of regulators to detect overfishing has been dramatically reduced compared to the 1980s, and secondly the lack of information between companies and fishers plausibly leads to a situation where both of them suspect that the other is overfishing. Third, the quota length was changed from one year to 10 years. This reduced the focus on attracting quotas each year, since the default expectation was that the quotas would last a decade as long as regulators did not catch them conducting any illegal fishing practices.

Because of this we will expect that the new quota holders prefer to overexploit the resource, regardless of what the companies do ($\Delta > \Gamma$, and $\Phi > \Lambda$). Similarly, the companies have an incentive to overexploit the resource since the payoff from overexploiting is attracted wholly to each company, whereas the cost, in terms of lower future yields, is spread across all players ($\gamma > \alpha$, and $\delta > \beta$). The outcome predicted in this strategic interaction is for companies to choose to overexploit the resource, and for new fishers to do the same. This is represented by the Nash equilibrium of (Overexploit, Overexploit), yielding payoffs of (δ, Λ).

This is a classic *tragedy of the commons* dilemma, as first noted by Hardin in 1968.[3] As with the commons, each quota holder concludes that he should catch more fish as the cost of doing so is shared by all fishers, whilst the benefits are apportioned only to the fisher that catches more. The preferred strategy of each player is to opt for personal gain over restraint, leading to the overexploitation of the resource. This has clear implications for the management of the resource, which we will discuss later.

We have seen that the decade prior to transformation was characterized by a comfortable relationship between regulators and the industry, leading to a high degree of cooperation and co-management of the resource. Unfortunately however, the *interregnum* period was not characterized by the same degree of co-management. When regulators lost the discretion to allocate quotas to a select few companies, the existing equilibrium was disturbed. When we use our model to evaluate the 1990s we find that the game has changed significantly. The previously excluded fishers now have a significant role to play, whereas the once pivotal role regulators played has been reduced entirely. An assessment of the incentives of those players in the game reveals that the game takes for the form of a classic tragedy of the commons dilemma, in which each player prefers overexploitation to restraint. Indeed, this is evident from the yield of the resource during this period - while the 1980s were particularly stable, the 1990s shows a sharp decline in yields. Before we discuss the implications of this finding however, we present a selection of potential confounds to the above model to determine the robustness of our specification.

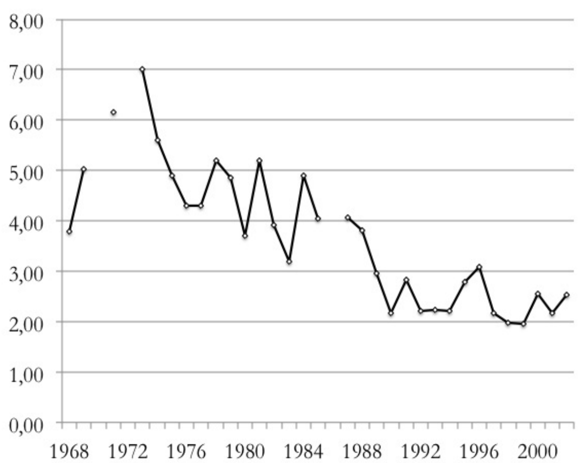
[3]The sole difference here is that we are dealing with two players, whereas Hardin (1968) used a metaphor involving numerous players.

3.5 Possible confounds to this explanation

There are possible confounds that potentially complicate our analysis above. Here we present a description of two of the most supported, along with reasons why we will discard these claims. The two main confounds are the reduced growth rates experienced during the early 1990s, and the increased incidence of large lobster mortalities.

While these issues do not alter the structure of the interaction, they offer potential reasons for why yields declined so markedly in the 1990s. Were these hypotheses to be true, they would complicate our model, which predicts that the decline of the resource was primarily due to overexploitation.

Figure 14: Annual growth rate of a 70mm male West Coast rock lobster between 1968 and 2001



Source: Author's construction, Johnston and Butterworth (2005).

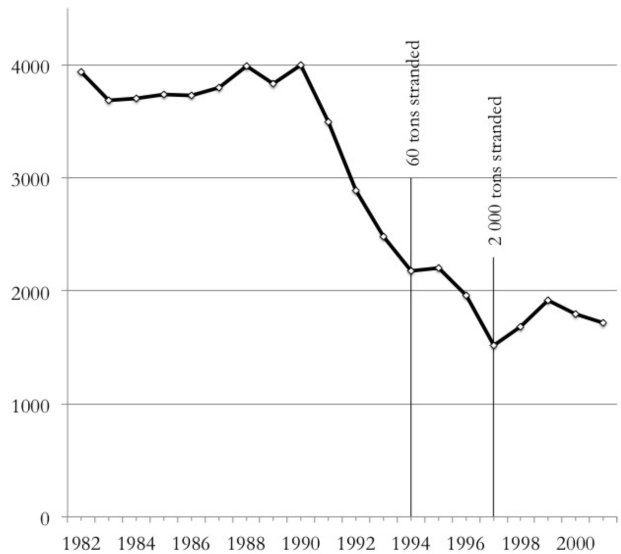
In 1989 the growth rate of West Coast rock lobsters dropped substantially (figure 14). Carapace growth of at least 4mm per year had been common up until 1990, however subsequent growth rates were closer to 2mm in most regions, and even negative in some (Cockcroft and Goosen, 1995). It is still not fully understood why this occurred, however the widespread nature of the growth reduction is indicative of a large-scale environmental cause, possibly linked to the *El Niño* phenomenon (Pollock and Cockcroft, 1997). Others have hypothesized that the strict adherence to the 89mm *CL* restriction resulted in genetic selection for slow growth (ORLAC, 1989, Tony Leiman, Associate Professor, UCT, personal communication, April 29, 2011). In terms of this hypothesis only the fastest growing lobster would be extracted, causing the proportion of slow growing lobster in the population to increase over time. The *CL* restriction may have also caused a large proportion of undersized lobsters to be caught accidentally, and perhaps injured before being returned to sea, retarding their future growth rates (ORLAC, 1989).

Over and above the slow somatic growth rates experienced in the 1990s, lobster mortalities in the form of "walkouts" were experienced on a massive scale (Cockcroft et al., 2000). Decay of unusually intense phytoplankton blooms rob the ocean of vital oxygen, causing lobsters to move into very shallow regions near the shore. During spring tides these lobster may become stranded in the shallows when the tide recedes, where they die in hot sunlight (Peschak, 2005). Approximately 60 tons of lobster washed ashore during one event in 1994 and some 2,000 tons were stranded in another event in 1997 - the worst mortality ever recorded in South Africa (Matthews and Pitcher, 1996, Cockcroft, 2001).

As mentioned above, if these hypotheses are true they complicate the predictions made by our model, specifically that the decline in the resource was primarily due to overexploitation, not environmental factors. There are however some reasons why the confounds presented above may not be valid. To assess the validity of the reasons given for the decline in somatic growth rates first, we must note that *El Niño* is a long term cyclical climate pattern (Trenberth et al., 2007). It would then not make sense for this to have such a significant effect on growth rates in the early 1990s, but not at any other point in time. Another fact we should consider is that the *El Niño* phenomenon was significantly stronger during 1988 and 1989, than the previous few years (Pastor, 2006). If the *El Niño* hypothesis were true we would expect stable growth rates leading up to 1989, and a large decline in that year, but this is not the case. As can be seen from figure 14, the decline in the growth rates began as far back as the early 1970s.

In fact what figure 14 shows is a prolonged decline in growth rates between roughly 1970 and 1990, and a stabilization from then onwards. Compare this to figure 15 which shows a decline in the TAC from 1990 onwards, indicative of a decline in the resource over that period. It would seem then that the two phenomena are not correlated very well over time.

Figure 15: Total allowable catch of the West Coast rock lobster between 1982 and 2001



Source: Author's construction, Melville-Smith and Van Sittert (2005).

Turning our attention to the mass stranding hypothesis, we note that a small stranding occurred in 1994 and the largest stranding occurred in 1997. Once again the decline in yields begins in 1990 and predates the occurrence of mass strandings by some years. We therefore conclude that the above two confounds are not well supported by the data.

Given this, we return to our earlier postulation that the overfishing was the most important factor leading to the decline of the resource. Although data on illegally harvested rock lobster is obviously very difficult to capture, there is much anecdotal evidence to support our hypothesis that mass overfishing existed during the 1990s. In a landmark case held in the United States (US), a South African lobster exporter and a US importer were found guilty of illegally harvesting roughly US$55 million worth of lobster in South Africa between 1987 and 2001 (Hlongwane, 2011). The accused were found guilty of poaching two different species of lobster, underreporting catches to fisheries authorities, bribing South African fisheries inspectors, and harvesting lobster way in excess of legal quotas. The court was told that between 1999 and 2001 93 percent of all lobster processed by the accused were illegally poached, and that between 1987 and 2001, the company illegally harvested nearly 800 tons of South Coast rock lobster alone (Anonymous, 2008). More recently, it is estimated that illegal poaching of West Coast rock lobster increased by roughly 54.4 percent per annum between 2008 and 2011 (Susan Holloway, Senior Research Officer, UCT Marine Resource Assessment and Management Group, personal communication, April 6, 2011). The model predicts that the decline in the resource was driven chiefly by overexploitation, something that seems to be upheld quite well empirically.

Given that the confounds presented above are not validated by the data, we can conclude that the decline in the resource was likely because of overexploitation rather than environmental factors. Our model therefore, seems to correctly account for the resource's decline in the 1990s. In the next section we move on to discuss the implications our model provides for the effective management of the resource.

4 Implications for policymakers

As discussed previously, the model we have built shows that the fishery currently takes the form of a classic tragedy of the commons dilemma in which players in the game each have the incentive to overexploit the resource. This differs dramatically from the 1980s period in which fishers had the incentive to maintain the fishery. Given the current structure of the fishery, and the incentives of each player in the game, if the fishery was left unregulated the resource would likely be depleted over time. In order to avoid this outcome, policymakers would be served by being cognisant of the dilemma they face and also of the potential solutions to this dilemma. While it is not the task of this research to propose a full alternative fisheries policy, in the fourth section of this research we will provide a discussion of the policy implications of our analysis, highlighting specific case studies from fisheries in other parts of the world, the lessons we can learn from these, and ending off with a note on the key impacts this research should have on policy development going forward.

4.1 How to solve the current tragedy of the commons dilemma in the West Coast rock lobster fishery

We can define the West Coast rock lobster fishery as a classic common-pool resource. Firstly, exclusion of beneficiaries through physical or institutional means is especially costly, and secondly, exploitation by one user reduces the resource availability for others (Ostrom et al., 1999). These two characteristics create the potential for the tragedy of the commons dilemma to exist, in which individuals follow their own short term interests to produce outcomes that are not in anyone's long term interest.

Two primary solutions are available (Hardin, 1978). The first is the privatization of the resource. Ostensibly, this serves to protect the resource and moderate its use, however this often ignores pre-existing management and has been shown to sometimes result in worse outcomes than under the previous management regime (Ostrom et al., 1999). Further, this necessarily involves a degree of measurement and control, which in common-pool resources such as fisheries may be prohibitively expensive.

An alternative solution, often associated with Arthur C. Pigou, is to let the government own the resource and levy an extraction tax. Pigou (1920) showed that under certain circumstances the taxes charged will be identical to the price charged in an efficient market. Ostrom et al. (1999) argue that this solution ignores the original owners or users of the resource and often results in a group of disenfranchised, often indigenous, individuals. The logic of a Pigouvian solution has also been questioned by others, most notably by Coase (1960), who argues that the solution works so well only because the real problems are assumed away. In assuming that the costs of monitoring and gathering information are negligible, the solution is made theoretically perfect, but flawed in practice. Again, in the context of fisheries management the cost of monitoring cannot be assumed to be negligible.

A third solution, previously discarded by most economists, is to retain the resource as common property and let users create their own system of governance (Ostrom and Williamson, 2009). In her book entitled *Governing the Commons: The Evolution of Institutions for Collective Action* (1990), Ostrom argues against the belief that the existence of a common property resource necessarily implies a tragedy of the commons "dilemma" which requires privatisation or government intervention to solve. After a summary of available evidence on the management of common-pool resources she finds that "users themselves envisage rules and enforcement mechanisms that enable them to sustain tolerable outcomes." By contrast, she argues that governmentally imposed restrictions are often counterproductive because they either lack legitimacy or the requisite knowledge to manage effectively. In later work she highlights two cases of this: overgrazing in Inner Asia, as documented by Sneath (1998), and inadequate modern irrigation in Nepal, as documented by Lam (1998), as well as a selection of other more minor failures of governments to manage common-pool resources effectively (Ostrom and Williamson, 2009).

To summarize succinctly her findings from many decades of work on this dilemma, she offers a set of eight *design principles* which have been found to exist in many stable common-pool resource management regimes.

We present these principles, as outlined in her book, with a brief discussion of each.

1. Well-defined boundaries exist: Boundaries between legitimate users and nonusers, as well as of the resource itself, must be clearly defined.

2. Rules regarding the appropriation and provision of common-pool resources are adapted to local conditions: Ostrom (1990, 1999) is very clear that no single set of rules work efficiently, fairly, and sustainably in relation to all common-pool resources. Rules should be adapted in some way to local conditions, to account for, amongst others, spacial heterogeneity, culture, ideologies and customs.

3. Collective-choice arrangements allow most resource appropriators to participate in the decision-making process: Ostrom (1990) states that "most individuals affected by the operational rules can participate in modifying the operational rules."

4. Effective monitoring by monitors who are part of, or accountable to, the appropriators: Monitoring of this kind makes those who do not comply with rules visible to the community, which facilitates the effectiveness of rule enforcement mechanisms. Further, since monitors themselves benefit from improved resource conditions, the incentives are more aligned.

5. There is a scale of graduated sanctions for resource appropriators who violate community *rules:* This serves to deter participants from excessive violations of community rules, but also to maintain social cohesion in that there is a proportionality between severity of the sanction and the violation.

6. Mechanisms of conflict resolution are cheap and of easy access: In order to credibly manage disputes, conflict resolution mechanisms must be rapidly accessible, and low-cost conflict resolution mechanisms are more likely to be sustainable and utilizable.

7. The self-determination of the community is recognized by higher-level authorities: External government agencies do not challenge the right of local users to create their own institutions. Government may aid the local users to create and enforce these institutions, but do not impose rules and regulations that undermine local efforts.

8. In the case of larger common-pool resources, organization takes the form of multiple layers of nested enterprises: Appropriation, provision, monitoring, enforcement, conflict resolution and governance activities are organized in multiple layers of nested enterprises.

It is worthwhile noting that the current fisheries policy contravenes Ostrom's design principles in many respects. For example, although legitimate users and nonusers can be defined by whether they hold a quota or not, it is not clear that those without quotas should remain excluded from the allocations. Guidelines for medium- and large-scale companies are quite clear, however there does not exist the same degree of clarity at other levels in the industry. For example, it is very difficult for regulators to determine which subsistence fishers should have a right to fish, and which should not. The Minister realized this first hand when a public outcry followed the 2005 allocations (Daniels, 2007). He subsequently doubled allocations that year to placate many *bona fide* fishers who were excluded in the first instance.

Further, monitoring is not done by those who are part of or accountable to the fishers. Monitoring falls within the ambit of Marine and Coastal Management and is conducted by poorly paid individuals with little incentive to actively prevent poaching (Peter Foley, Chief Executive, West Coast Rock Lobster Association, personal communication, May 20, 2011).

While this research does not intend to propose a full set of solutions to the problems faced in the West Coast rock lobster fishery, the model used herein implies that policymakers might be served by being cognizant of the tragedy of the commons dilemma and the solutions available. In this section we have highlighted the current thinking around potential solutions, with a special focus on the work of Elinor Ostrom.

We now move to present two case studies of experiences in New Zealand. Not only is New Zealand the paragon of devolved fisheries management regimes, but it is also a country which faces many of the same challenges South Africa faces in terms of groups of disenfranchised fishers, and high-value and easily accessible fisheries like the rock lobster. As we will see fishery management in New Zealand displays many of Ostrom's design principles, and has seen a resurgence in the stocks of many key resources in the last decade.

4.2 Deep-sea crabs in New Zealand

This case study of the deep-sea crab fishery in New Zealand reveals that this industry currently displays a very similar industry structure as the West Coast rock lobster fishery in the 1980s, and serves to affirm our previous analysis. It further allows us to understand the environment that needs to exist for us to return to the structure of the industry in the 1980s.

This fishery is characterised by landings of king crab (including, *Neolithodes brodiei*, *Lithodes murrayi*, and *L. longispinus*), red crabs (*Chaceon bicolor*), and giant spider crabs (*Jacquinotia edwardsii*) (Naylor, Webber and Booth, 2005). King crabs and red crabs tend to be found in a similar habitat in moderate to deep waters off the northern island of New Zealand. Spider crabs live at depths from intertidal to 550 meters, and are predominantly found in the southern New Zealand waters.

In 1986, 27 species were introduced into the New Zealand Quota Management System (QMS), a system used to manage commercial fishery harvests on the basis of individual transferable quotas (ITQ) (Townsend and Shotton, 2008). The QMS implementation gained traction in 2001 when many new species were introduced into the QMS as a part of the *1996 Fisheries Act* full implementation (Craig and Soboil, 2008). By 2003 there were over 60 species in the QMS, and today there are over 100 species managed within this framework.

At the beginning of each fishing year, quota owners receive"annual catch entitlements" (ACE), which provide them with authorization to catch an amount of fish equal to their respective share of the TAC. The QMS developed into a hybrid system which employs both quantity (in terms of the ACE), and price instruments (here known as "deemed values"). Deemed values are civil penalties paid to the state for landing fish in excess of your ACE (Newell, 2004).

In the past, initial quota allocations for a QMS species were made to fishers on the basis of the historical harvests of fish by that fisher. When the historical catches resulted in allocations less than the commercial catch limit the remaining quota went to the state. The New Zealand Ministry of Fisheries sold this remaining quota by an open public tender.

In 2004, it was deemed that quotas for all future species introduced into the QMS was, with some limited exceptions, subject to a tender process rather than by allocation according to historical catches. For Maori, the indigenous group of the population of New Zealand, the Treaty of Waitangi ensured twenty percent of all new quota species, and ten percent of all species allocated prior to 2004, would be purchased by the state and made available to the local Maori inhabitants.

The change from catch history allocation to public tender avoided a 'race for catch history' in fisheries that were soon to become involved in the QMS. The Ministry of Fisheries also instituted a moratorium on new non-QMS permits for this reason (Craig and Soboil, 2008).

This fishery is noteworthy because of the development of a governance framework to focus on collective objectives throughout the entire value chain, from harvesting, processing, and marketing to fisheries management. This section examines the gains from the cooperative management, collective action and self-governance by rights holders, and is particularly pertinent for us given the structure of the West Coast rock lobster industry in the 1980s as explored earlier in this research.

In 2006, deep-sea crab in waters surrounding New Zealand were brought into the QMS through open tender. All quotas were allocated to the highest bidder through tender, and based on the 2004 amendments to the Fisheries Act there were no allocations based on catch history. Four New Zealand entities acquired 90% of the deep-sea crab quota, and facilitated the development of "Crabco" - an institution with the goal of maximising the long-term productivity of the stock and to add to quota value by, among other things, determining if the biological characteristics of the species could sustain higher yields (Townsend and Shotton, 2008).

When the rights were first tendered to the public, the TAC was set at a very conservative level, reflecting the limited knowledge about the biological characteristics of this resource. Crabco could enhance robust scientific research and supply accurate fine scale catch and landing reporting, which would ultimately have the effect of increasing the TAC, and therefore participants' quota holdings. Crabco began harvesting king and red crabs in May of 2007, using a harvest plan geared to collect data that would help estimate abundance and spacial distribution across the various catchment areas.

This type of active involvement in policy-making is inherent to the deep-sea crab quota owners as many of them had been involved in other quota species and their policy development. They learned from these previous encounters that without a devolved fishery management process, unnecessary economic costs and sub-optimal fishing rules would be imposed (Craig and Soboil, 2008). These deep-sea crab fishers seem to have known the economic benefits of good fisheries management, and the importance to review and monitor TACs, and other fishing rules for improved resource management.

In order to derive these economic benefits, the deep-sea crab fishers developed the Crabco model. Much in the way Scott (1955) first proposed, it was based on the premise of a sole owner, where quota owners entrusted the management of their rights to the company specifically geared towards maximising their quota values. In terms of this arrangement, at the beginning of each year quota holders transferred their ACE to the company. The company was then responsible for delivering the following:

- Strategic plans, which were signed off by shareholders prior to implementation,
- Internal and external communications, including liaising with the Ministry of Fisheries,
- Planning and management of harvesting and processing,
- Provision of marketing services, and
- Quality assurance in operational delivery.

In every way Crabco acts as a unified company. It aims to maximise the profit of its shareholders throughout the value chain in terms of efficient harvesting methods and processing methods, as well as through effective marketing. The company returns its profits back to shareholders through a transparent accounting process. Robust and thorough analysis is given to all shareholders and all profits are distributed to quota owners as specified in their ACE transfer agreements (Craig and Soboil, 2008).

Profits are calculated for each species and are roughly equal to the total revenue from the sale of that species, less all costs incurred to make those sales. These costs would likely include the cost of harvesting, processing, marketing, and the general management costs. Profits are then divided among the members in proportion to their share of the ACE that each owner transferred to Crabco at the beginning of that year.

Quota holders have signalled their intention to protect the resource by making a commitment to a two-year development phase for each new quota holder. In terms of this, any profits generated during those first two years are to assist in the further development of the fishery.

Voting rights in Crabco are proportional to the value of the ACE sold by that quota holder to Crabco in the previous year. If, for example, a certain shareholder received 19% of Crabco's profits last year in accordance with the ACE he sold to the company at the beginning of that year, he will be entitled to 19% of the voting rights in this year.

With the establishment of Crabco, the members began developing a management plan for the deep-sea crab fishery. The company acts as a representative of all deep-sea crab fishers and in addition to providing the research support mentioned earlier, liaises with government entities on a regular basis with a view to being actively involved in the management of the fishery. This clearly shows how Crabco does not only harvest the resource, but also accepts management and development responsibilities.

As Hønneland (1999) predicts, when resource users are involved in rule-making and management activities compliance levels improved dramatically. With stakeholders now actively involved in policy decisions, the industry has taken ownership of difficult decisions. Specifically, quota holders have agreed to use only crab pots, rather than trawling, as a way of avoiding the environmental impacts of that kind of fishing method. Crabco members have also agreed to increase deemed values, which will deter free riders from entering the industry and help manage bycatch in the scampi fishery.

The original tender of quotas in new and developing fisheries created a perfect opportunity for self management. For deep-sea crabs, the development of Crabco has created more responsive, efficient, and targeted management decisions that benefits the rights holders and the fishery as a whole.

Overall, this model of self-management of the deep-sea crab resource has yielded accurate scientific reports, increasing TACs, full extraction of rents along the value chain, and a resource that is seemingly guaranteed to be protected well into the future.

As discussed in an earlier chapter of this research, the West Coast rock lobster industry in the 1980s had a very similar structure to this. Although some differences exist, specifically in terms of harvesting and processing the resource, the unified single-firm approach originally envisioned by Scott (1955) has once again been shown to be successful in developing successful, industry-supported management policies. These policies are made with the best possible information, and have high rates of compliance as predicted by Ostrom (1990).

Unfortunately, this has little impact on South Africa fishery policy going forward. A necessary condition for this type of industry structure is that the quotas are held by a small number of like-minded fishers - in the New Zealand case only 4 entities, and in the South African case only around 40 entities. Given the current state of the industry structure, with over 200 quota holders, it is unlikely that this method of creating a single firm to harvest, process, market and guard the resource will be able to be created. Despite this, the case study presented here further underscores our analysis of the 1980s as being correct.

4.3 Rock lobster in New Zealand

In this section we cover the rock lobster fishery in New Zealand, which has developed a system of governance over decades that meet many of Ostrom's design principles, and is widely regarded to be one of the most successful instances of common-pool resource management. This serves as a case study for South African fisheries policymakers, and should have direct impact on how policy is modified going forward.

Rock lobster has a long history of exploitation in New Zealand. The Maori, who arrived on the islands somewhere between the 10th and 14th centuries, consider rock lobster to not only be historically significant, but culturally significant too (Annala, 1983).

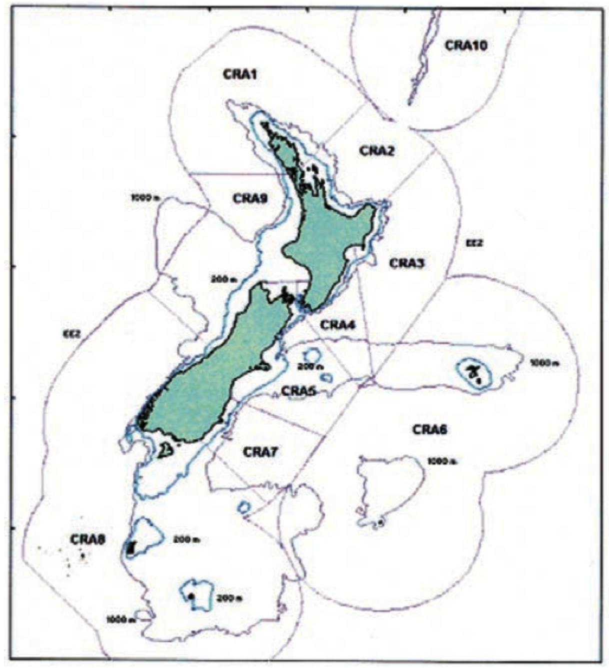
Two species are indigenous to this region, *Jasus edwardsii* and *Jasus verreauxi* . These rock lobster are harvested primarily with lobster pots boats with one or two crew members. These lobster are largely caught to be exported live to Asian markets (although some are sold frozen to the United States) and is the fourth largest export species in New Zealand (StatsNZ, 2013).

Recent fishery stock assessments define the resource as stable or recovering from a previous period of over-fishing, although large degrees of uncertainty still remain due to incomplete information on recreational catches and the degree of illegal fishing (NRLMG, 2002).

Boom and bust cycles characterise much of the history of the rock lobster fishery in New Zealand. In a similar fashion to the rock lobster fishery in South Africa, a sharp run up in yields in the 1940s and 1950s was experienced during this time, with minor peaks and valleys evident in catch and catch per unit effort.

In this case study we will focus on the most common species, *Jasus edwardsii*, which is divided into nine geographical regions along the coast of New Zealand (as shown in figure 16). These regions correspond with regional rock lobster industry organizations or "Crayfish Management Advisory Committees", commonly called CRAMACs, which are key to lobster management in New Zealand.

Figure 16: New Zealand rock lobster management areas, and geographical distribution of CRAMACs



Source: National Rock Lobster Management Group, 2005.

"Policy Statements for the Rock Lobster Controlled Fishery" introduced the fishery to "controlled fishery" status in 1980 (Annala, 1983). As a controlled fishery, rock lobster permits were distributed by the Fishing Licensing Authority (FLA), in terms of which permits were given to fishers with a long-term commitment to the fishing industry and earned at least 80% of their income from fishing. Note that this was from fishing generally, not from lobster fishing only. As Annala (1983) records, in that year the number of commercial rock lobster fishing permits dropped by 38%.

These permits correspond to one of the nine geographically distinct fishing regions mentioned above. The Fishing Industry Board (FIB) organized a liaison committee for each region consisting of fishers and processors who provided input into fishery management. A national level liaison committee consisting of a representative from each region was also created. The formation of these national, and more micro-level committees was a critical step towards co-management of the resource - a topic we will soon investigate.

While these reforms continued in the rock lobster fishery, the broader New Zealand fishing industry went through a period of fundamental changes. In 1986, New Zealand became one of the first countries to adopt market-based regulation when it initiated the QMS as discussed in the previous case study (Crothers, 1988).

Although rock lobster was not included in the first stage of the QMS rollout, it, along with paua (abalone), were first to be put forward as pilot fisheries. As Yandle (2008) describes, the Ministry of Agriculture and Fisheries (MAF) originally approached the New Zealand Federation of Commercial Fishermen in the early 1980s and sought to use paua and rock lobster as pilot fisheries for the introduction of ITQ management. The Federation considered this, but rejected the proposal because the two fisheries appeared to be healthy at that time, and the Federation was concerned about a system which involved setting a total allowable catch, thereby limiting the resource they could extract each fishing season. Despite this, the QMS was eventually introduced in the fin fisheries first.

As the rock lobster looked to be under more pressure, the issue of bringing rock lobster into the QMS was reexamined by stakeholders (Branson, 2005, as cited by Yandle, 2006). Discussion first took place at the national level between the National Rock Lobster Liaison Committee and the FIB (Duncan, 1985). Both the Liaison Committee and the FIB prepared their own briefs to aid discussions (MAF, 1986) and after two rounds of discussions two options were left on the table - institue ITQs under the QMS, or keep the existing controlled fishery policy with the addition of TACs. On 16 April 1987 the votes fell in favour of introducing the fishery to the QMS (Yandle, 2008).

Originally the rock lobster was intended to be added to the QMS in 1988, however the Treaty of Waitangi effectively pushed this change into 1990 (Moon, 1999). In the end the *1989 Maori Fisheries Act* brought the rock lobster into the QMS in the 1990 fishing year.

In accordance with standard QMS protocols, the total allowable catch of this fishery was reduced in 1989. The exact reduction differs per region, however the most significant decline was said to be experienced in the Southern region which dropped their TAC by 35.1% (MAF, 1990).

Immediately subsequent to this change the fishery experienced turbulence in terms of both setting the TAC and also a series of national and regional initiatives on approaches to maintaining or improving the fishery. These events developed a micro-level involvement of the committees and promoted an environment of co-management between government and industry.

Apart for holding discussions around the setting of the TAC, industry also participated in the broader consultative process around management. The Rock Lobster Steering Committee was convened by the Minister of Agriculture and Fisheries in 1991 to develop a management plan in consultation with industry. This was composed of commercial fishers, recreational fishers, Maori stakeholders, and conservationists. Pointedly, the MAF saw this as a "shift towards a new management approach based on the direct involvement of user interests in the formulation of a forward-looking fishery plan" (Yandle, 2008). The final plan recommended that instead of focussing on a national plan using TAC reductions as its main tool, the strategy should focus on regionally tailored efforts such a cracking down on illegal fishing, handling protocols, and changes in size restrictions. Finally the plan recommended that a National Rock Lobster Management Group (NRLMG) be created to advise the minister on the management of the fishery.

Since this time, the industry continues to engage with the government in developing various initiatives to stabilise or increase the stock of rock lobster. These include,

- *Supplemental Enforcement Initiative:* In 1993 the MAF and the FIB contracted additional enforcement to target illegal fishing in both the commercial and non-commercial sector. This was paid for out of an additional levy of commercial rock lobster fishers.

- *Data Gathering Programmes:* Collecting data on the stock of rock lobster is an important part of the management process. The industry has actively and progressively developed monitoring initiatives such as keeping logbooks and facilitating tag and release programmes.

- *No Tag/No Sale:* A problem with many rock lobster fisheries is illegally caught produce reaching the retail and hospitality industries. The rock lobster fishers, in conjunction with FIB, introduced a programme to identify legally caught lobster with special tags.

- *A Tailored, Regional Harvest Strategy:* In the early 1990s stocks in one particular region, CRA3, were in significant decline. Commercial, recreational, and traditional Maori fishers formed the CRA3 Users Group to develop a tailored harvest strategy to deal with the regions decline. While these users were concerned with the sustainability of the resource, the day-to-day livelihoods of many fishers depended on lobster yields. For this reason a strategy with two fundamental goals was drafted: first, to reduce catches in order to prevent to collapse of the resource, and second, to increase the landed value per lobster in order to compensate for the reduction in yields. The key initiatives introduced by this group were: eliminating half of the TAC for three years, closure of the CRA3 fishery for three months to all fishers, movement of the open season to Winter when prices are higher, increased enforcement targeted towards poachers, and decreasing the minimum catch size of males. The reduction of minimum catch size was not without controversy, however the Ministry of Fisheries evaluated this proposal using an acknowledged mathematical model and eventually accepted the strategy. The outcome of this has been a marked increase in the stock of the resource, along with increased catch rates of larger lobster. The creation of this harvest strategy has been highlighted as a key moment in generating momentum for co-management of the fishery in New Zealand. Not only were the fishers able to use their superior knowledge of the fishery to accurately identify the true problems faced, but they were also given the space to create innovative and tailored responses to these problems. For a full discussion see "A fisheries management success story: the Gisborne, New Zealand, fishery for red rock lobster (*Jasus edwardsii*)" by Breen and Kendrick (1997).

While not all of these initiatives were successful they did demonstrate how actively involved in resource management the lobster industry became during this period. The 1990s goes down as a key period of time in which rock lobster stakeholders at both the national and regional level espoused management of the resource as a key part of their roles. As this momentum continued, stakeholders agreed on the development of the New Zealand Rock Lobster Industry Committee (NZ RLIC) and its relationship to the regional CRAMACs. According to Yandle (2008) this became finalised in 1999 when legislation was passed that allowed government to delegate certain fisheries management responsibilities to Commercial Stakeholder Organisations, which provided the space for industry to grow in this role.

In terms of the NZ RLIC formation, this body would be an umbrella organisation composed of the regional CRAMACs. As mentioned earlier, the geographic boundaries of these CRAMACs are based on the regional quota management areas for species *Jasus edwardsii.* While exact membership rules vary in each CRAMAC, the aim is for each CRAMAC to attract quota holders, permit holders, processors, exporters and all other stakeholders. Each CRAMAC appoints one executive to the NZ RLIC and contributes to the national organizational budget in proportion to the TAC granted in that region. The NZ RLIC, as a national body, represents the industry in engagements with government, MAF, and FIB.

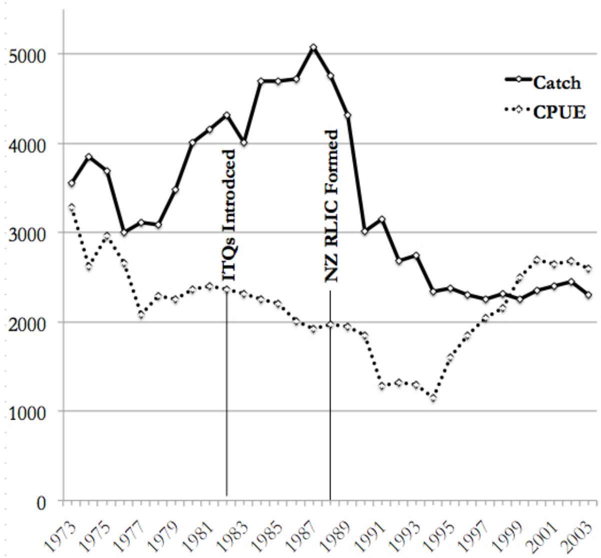
In 1997 another key step in the evolution of this management framework occurred when stock assessment research contracts became individually contestable. The NZ RLIC, in conjunction with the newly formed New Zealand Seafood Industry Council (SeaFIC) fisheries scientists as well as the traditional provider, contested and won a one-year contract based on the concept of industry involvement (Yandle, 2006). Today the NZ RLIC consistently wins multi-year stock assessment research contracts.

Since the QMS and the later developments of devolved governance were introduced, catch levels have been reduced through TAC reductions, while catch per unit effort (CPUE) has increased (figure 17). Scientific stock assessments conducted recently appear consistent with the theory that the stocks are being safely managed, subject to the usual degree of uncertainty around recreational and illegal harvests.

However, the effect of these developments on the management process is more directly observable; there is clear evidence of increased stakeholder participation in the fishery management process. The NZ RLIC acts not only as a resource harvester, but also an advocate, a researcher, and a coordinator of activities for regional CRAMACs.

As Ostrom (1990, 1994) records and Vyrastekova and van Soest (2003) test empirically, the involvement of stakeholders in the research and rule-making process increases the likelihood that those rules will be followed and

Figure 17: New Zealand rock lobster (*Jasus edwardsii*) annual catch and catch per unit effort



Source: Yandle, 2006.

thus the robustness of self-management regimes are improved.

The development of devolved governance in the rock lobster industry in New Zealand was a multi-decade process. The emergence of NZ RLIC and CRAMACs involved both social capital and management experience within the industry and an expansion of property rights. According to Yandle (2003, 2006) the continuation of this approach throughout New Zealand's fisheries suggests that property rights and social capital development are key requirements for the successful development of devolved governance.

There are multiple lessons for South African fisheries policymakers from the analysis undergone earlier, as well as these two case studies. This will be discussed in the next section.

4.4 Conclusions and implications of this research for South African fisheries policymakers

This research began by assessing the history of the West Coast rock lobster in South Africa to find that the 1980s period stands in stark contrast with the general decline of the fishery. An in-depth analysis of the stakeholders involved in the game during this period allows us to conclude that it was the industry structure that lead chiefly to the stability in yields. Organizations such as SAFROC and CLEA acted together not only as harvesters and processors of this resource, but also as managers, much in the same way as Crabco did in New Zealand in the last decade.

An analysis of the current industry however, reveals that this industry structure no longer exists. A game theoretic analysis reveals that the fishery currently represents a classic tragedy of the commons in which stakeholders follow their own short-term interests and in doing so overfish to the point where the fishery is likely to be depleted.

Traditional economic thinking would suggest that we have two options to deal with this tragedy; privatisation or government ownership. These have in recent times been classified as archaic and out-dated, especially given high costs of monitoring fisheries and their likelihood to ignore the rights of indigenous fishers.

Nobel laureate Elinor Ostrom has been the chief proponent of a third option; devolved governance of common-pool resources. We have used a case study of the rock lobster fishery in New Zealand to explore potential ways this type of co-management of the resource has been established in practice.

With all of this in mind, this research naturally brings to the light the following policy suggestions.

1. Zones A and B, as well as the four sub-areas 5-9, as shown in figure 6 should be the boundaries for six regional committees of rock lobster stakeholders, who each report to a national committee of rock lobster representatives. The success of the regional system of CRAMACs, with a national-level NZ RLIC is clear from the rock lobster fishery in New Zealand. More importantly this will enable many of the following interventions to occur successfully.

2. We should facilitate collective choice arrangements which allow local stakeholders to participate in the management process. This would allow committees to determine rules that meet the challenges faced in that specific region. For example, in certain regions along the Northern section of the coastline poaching is openly practiced and rife among certain population groups. Those who drive along the road running parallel to the ocean are likely to see many cases of illegal rock lobster being sold openly along the roadside. This differs completely from the challenges faced in other regions. Using this local knowledge of the resource will aid policymaking and also engender a link between regulators and resource appropriators.

3. Regulators should recognize, within certain limits, the ability of regional committees to develop initiatives that meet the challenges faced in that region. As discussed above, different regions along the South African coastline suffer from different challenges. Creating regional committees is only worthwhile if government allows them the space to develop and implement targeted initiatives. The CRA3 tailored harvest strategy in New Zealand is one example of how when local committees espouse management of the resource, regionally defined rules can have great impacts on the resource.

4. Committees have cheap, easy methods of resolving conflicts, with graduated sanctions for those who violate rules. By devolving conflict resolution to the regional level and by empowering them to sanction violators, we empower the appropriators of the resource with monitoring powers. This has been proven to increase compliance in common-pool resources, and engender a kind of visible respect for the resource. Typical sanctions could include having quotas removed, banning further quota applications, fines, among other options. These sanctions should be escalated to the national level, and potentially to the regulators themselves before being actioned, as a check against abuse at the regional level.

It is important to realise that regulators cannot force stakeholders to accept their role in the management of the resource, however this kind of co-management of resources has been shown to be effective in many cases around the world. While the system of CRAMACs and the NZ RLIC took decades to develop organically, with this end in mind, and with a correct understanding of what type of dilemma the fishery currently faces, policymakers can begin the path to developing this kind of devolved governance system.

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